Aerobraking Maneuver #1
TARGET ALTITUDE

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- **Determine the Altitude Target for AB-1**
  - MOI at 313 km
  - Baseline Targeted 0.01 W/cm2 ≈ 138 km.
  - Main Phase   ≈ 0.4 W/cm2, 110 km.
  - Unsure of the Atmospheric Density.

- **Too High, Don't Sense the Atmosphere**
  - Harder to plan the next maneuver ?

- **Too Low, Burn Up.**

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- ## Procedure: Poll the Experts
  - What is the Highest altitude where the Density Might Equal the Critical Density, 143 Kg/km^3 ≈ 175° Redline Panel Temp.?

Richard Zurek	100 - 130 km
Todd Clancy	115 - 120 km
Jere Justus	132 - 154 km
Steve Bougher	124 - 134 km
Gerry Keating	140 km (Be Safe, not Sorry.)

- ## TARGET AB-1 to 135 km.
  - Expected period change per orbit $\approx$ 600 seconds is detectable.
  - Estimates Based on Perihelion, where density is greatest.
  - Highest Values from MarsGRAM have global dust storm.

- ## FEEDBACK:
  - Frank Palluconi is concerned that 135 km might be too low.
  - Some of the Estimates are Greater than 135 km.
  - Memo sent to the Experts that Provided Input for Review.
  - Justus: 154 km -> 143 km with new version MarsGRAM 3.4
  - Recent Clancy data seems to indicate a lower density.

CRITICAL SCALE HEIGHT

How are we going to use the "Atmospheric Density Measurement" During Walkin to Plan the Next ΔV ?

- ## Define the "Critical Scale Height" ...

  - The Scale Height as a function of Δh required to reach the "Critical Density" where the Panels might be Damaged.

  - $H_s{}^*(\Delta h)$ = the Scale Height where $Rho(h_o + \Delta h)$ = "Critical Density"

  - h_o = The Current Altitude

  - $Rho(h)$ = The Density at Altitude h. (Know $Rho(h_o)$)

  - Δh = The proposed altitude Change for the Next Maneuver.

  - "Critical Density" = 143 kg/km3 $\approx$ 175° Panel Redline.

- ## Is the "Critical Scale Height" for the Planned Δh LESS than the smallest REALISTIC value?
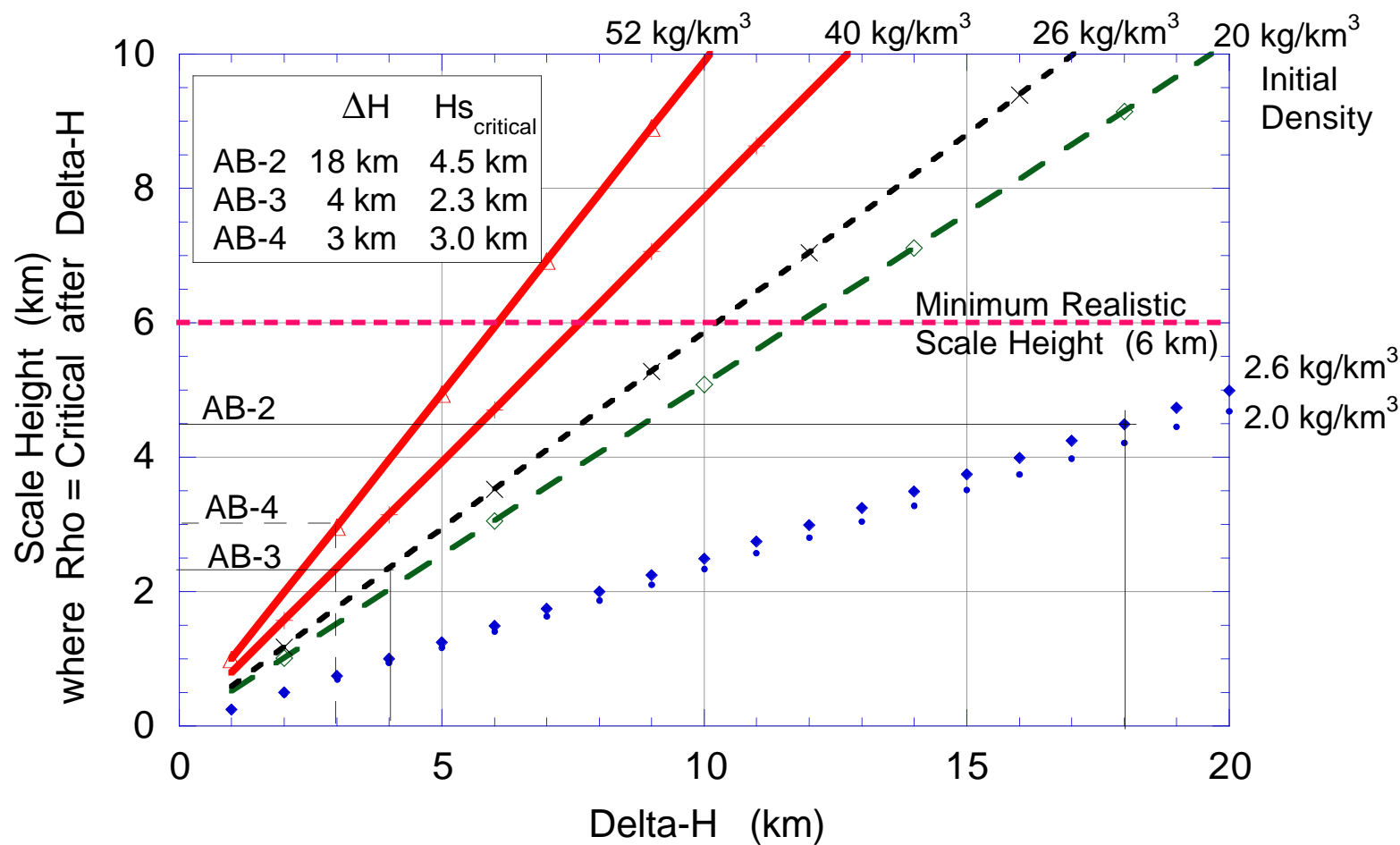
Exponential Atmosphere: $\rho = \rho_O \bullet e^{\left(\dfrac{h_O - h}{h_S}\right)}$

Solve for Critical Scale Height, h_s: $\quad h_S^* = \dfrac{h_O - h}{\ln\left(\dfrac{\rho_{CRITICAL}}{\rho_O}\right)}$

- Using ρ_o and h_o as the reference values, and
- $\rho = \rho_{Critical}$ at new altitude, h,
- Solve for the Scale Height.
- Small altitude changes $(h_o - h)$ = small h_s^* to get required density change.

Baseline & Proposed Walkin Maneuvers

Table 1: Baseline Aerobraking Maneuvers

AB-#	H_o (km)	ρ_O (kg/km^3)	$h_o - h$ (km)	DV (m/s)	h_s^* (km)	Qdot (W/cm^2)
2	135	2	18	0.72	4.2	0.011
3	117	20	4	0.19	2.0	0.10
4	113	40	3	0.14	2.4	0.20
Post AB-4	110	60				0.33

Table 2: Aerobraking Maneuvers with Equal Values for h_s^*

| AB-#	H_o (km)	ρ_O (kg/km^3)	$h_o - h$ (km)	ΔV (m/s)	h_s^* (km)	Qdot (W/cm^2)
2	135	2	**12.9**	**0.52**	**3.0**	0.011
3	**122.1**	**11.6**	**7.6**	**0.36**	**3.0**	**0.06**
4	**114.5**	**32.5**	**4.5**	**0.21**	**3.0**	**0.18**
Post AB-4	110	60				0.33

Planning Chart for Operations

Scale Height and Altitude Change Required to Reach CRITICAL DENSITY from Estimated Pre-Maneuver Density

Critical Density = 143 kg/km^3

Scale Height for CRITICAL DENSITY

- Hs* = 2 km
- **Hs* = 3 km**
- Hs* = 4 km
- Hs* = 5 km
- Hs* = 6 km
- Hs* = 7 km
- Hs* = 8 km

Estimated Density (kg/km**3)

Measurement

Delta-H (km)

Max. Planned Δh

If ACTUAL Scale Height is 8 km, a 16 km Δh would reach Critical Density
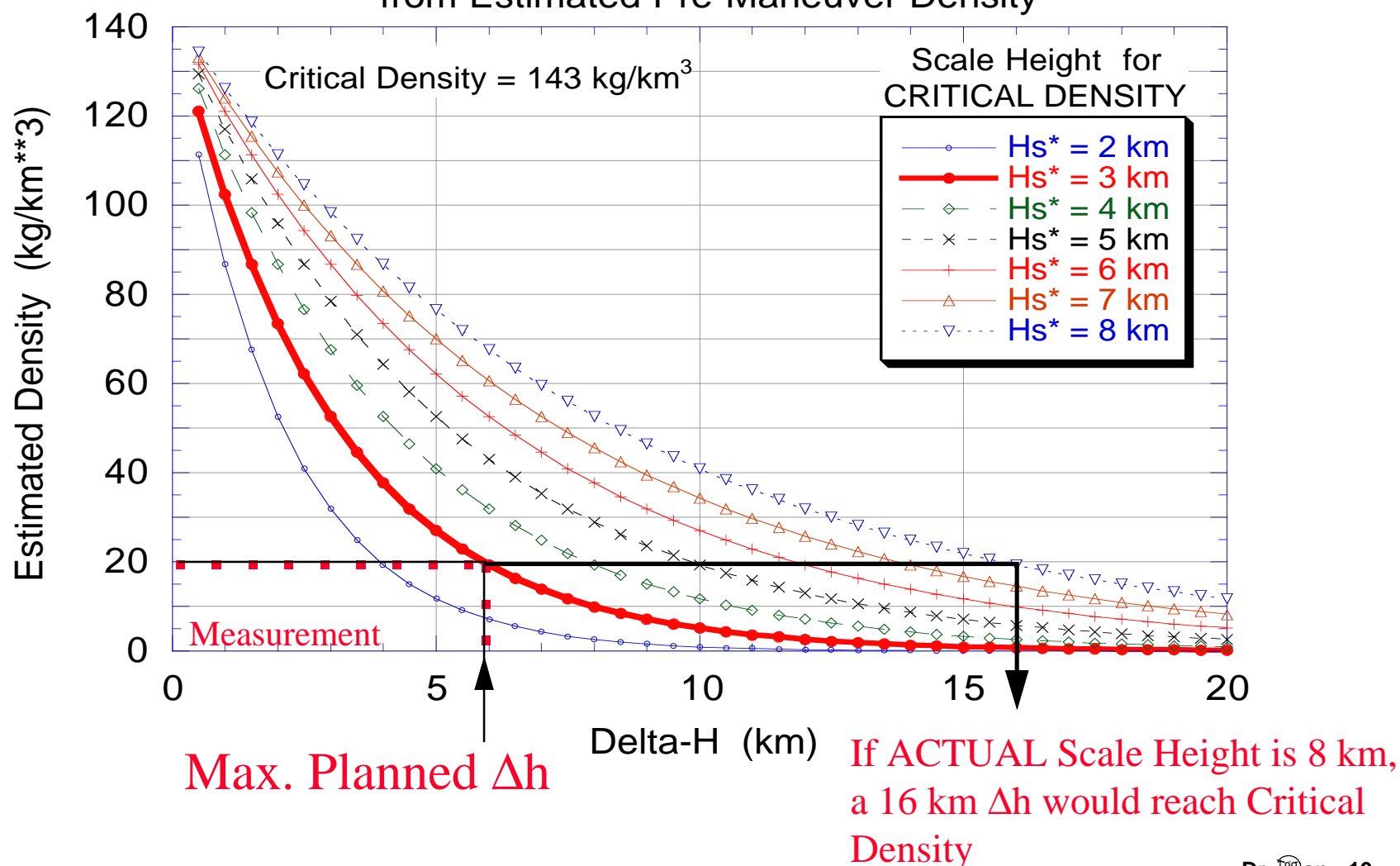
Fixed Maneuver Sizes   (3 km Hs*)

Scale Height and Altitude Change Required to Reach CRITICAL DENSITY
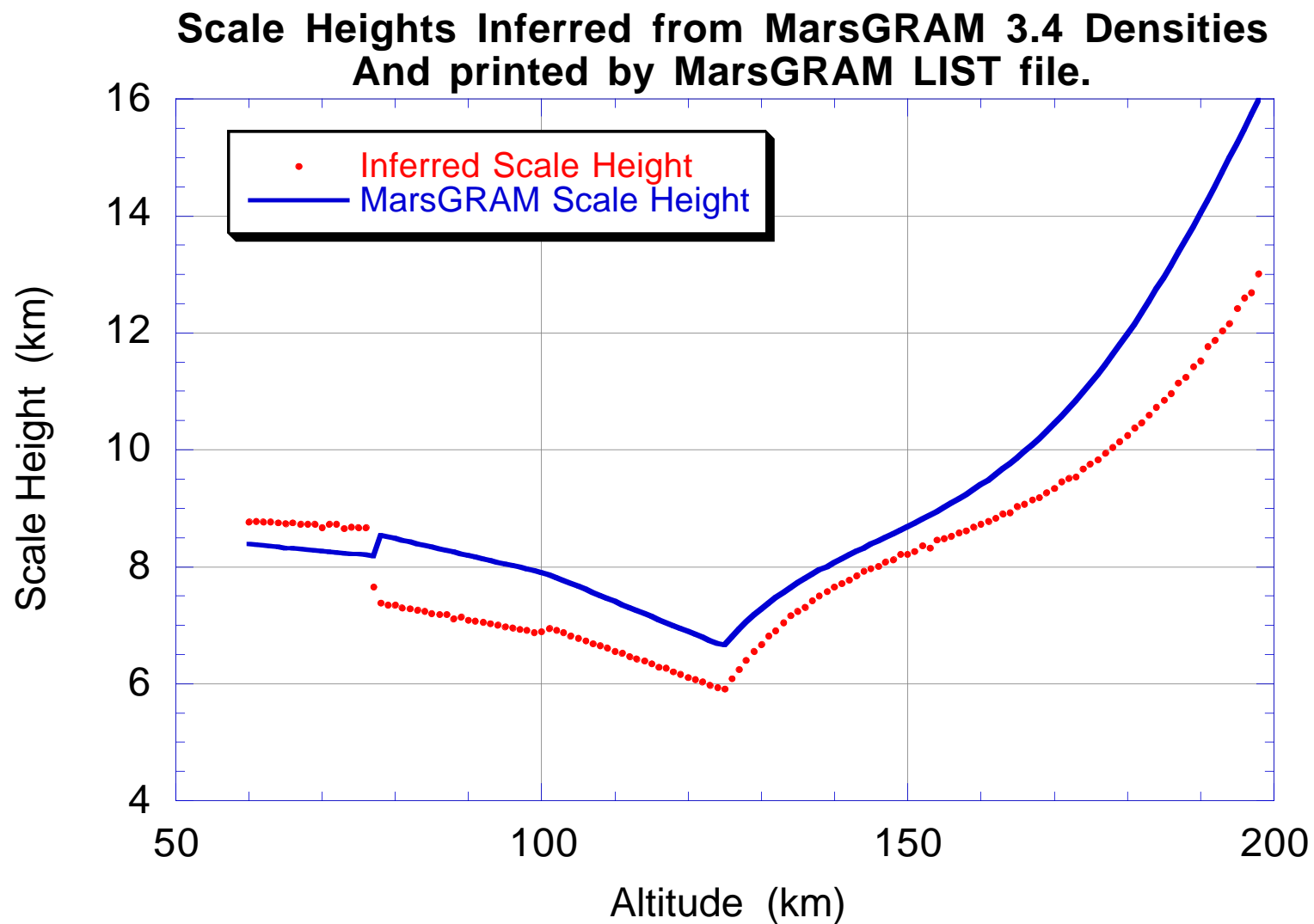from Estimated Pre-Maneuver Density
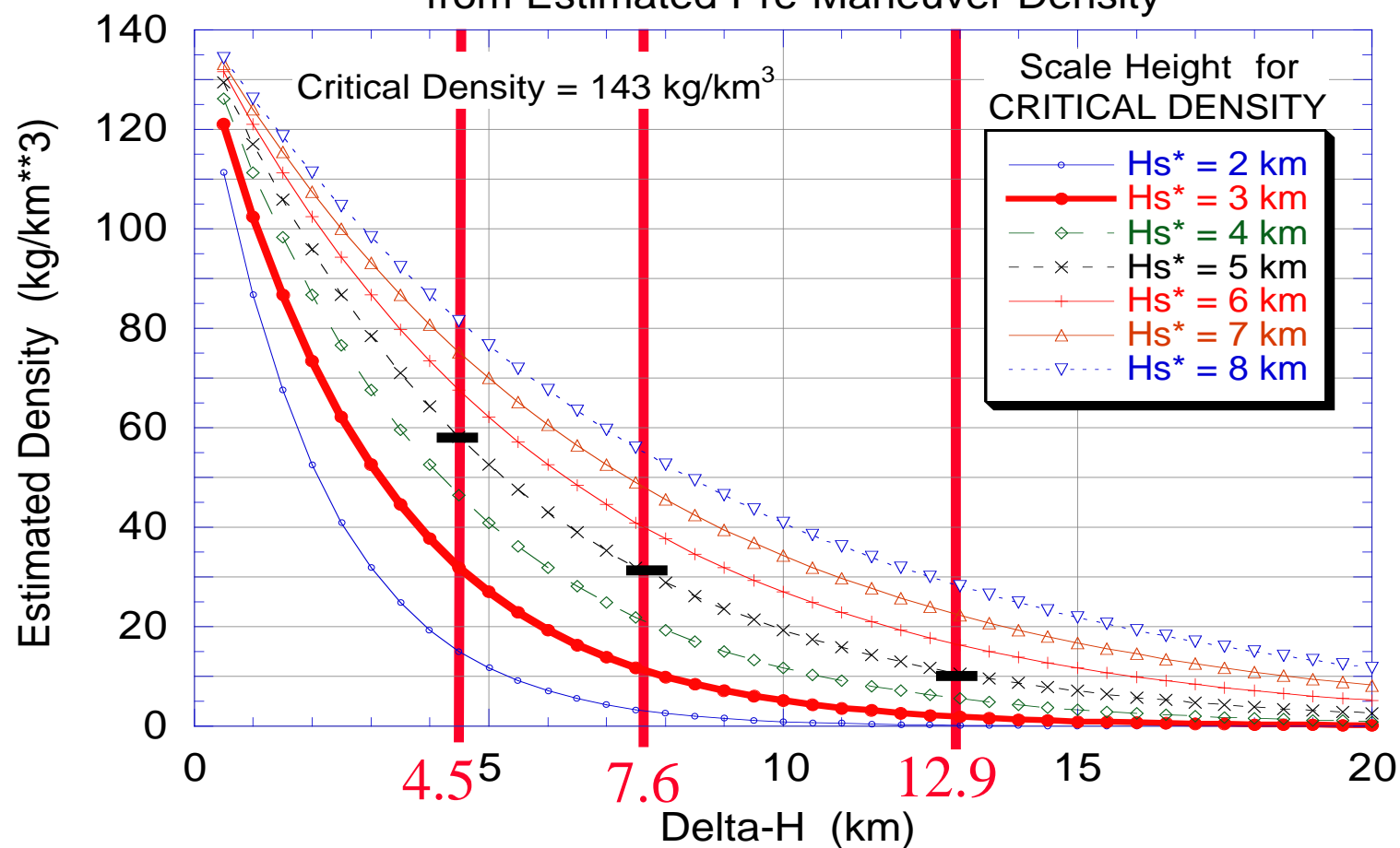
- Before Each Maneuver, Check if the Critical Scale Height is Much Less than a REALISTIC Scale Height.

- Minimum REALISTIC Scale Height is $\approx$ 6 km.

- Expected Scale Height 7 - 10 km.

- Designing Walkin for EQUAL Critical Scale Heights
  - Results is a Critical Scale Height of 3 km.
  - Half the Mimimum Realistic Scale Height.

- Possible to add Uncertainty to the Measurement before Testing the Critical Scale Height.

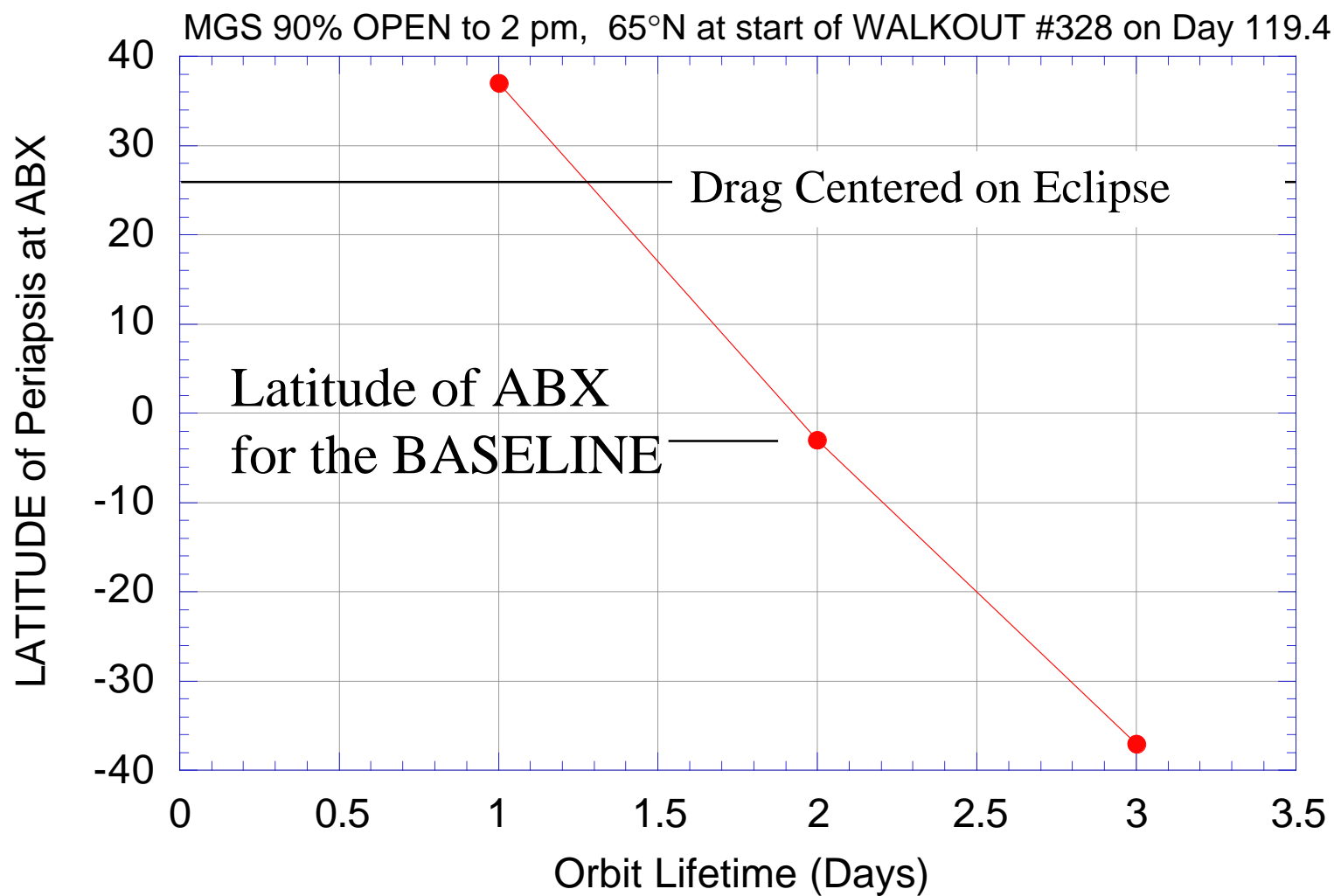**Mars Global Surveyor**

- **How Many Maneuver Sizes Can we Pick From ?**
  - The three "Nominal" Maneuvers ?
  - Something In Between ?

- **How Many Maneuver Sizes to "Guarantee" 3 Maneuver Walkin ?**

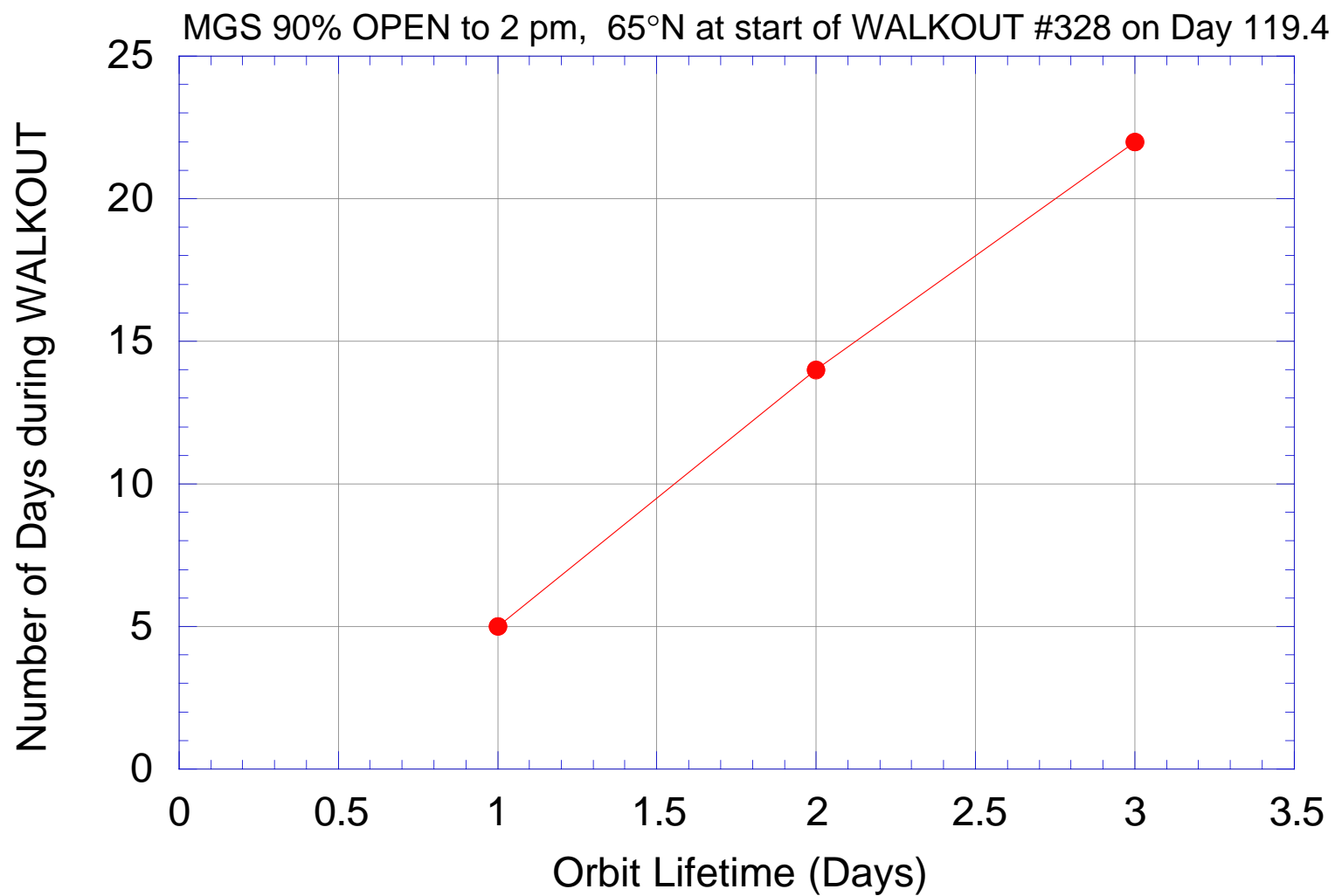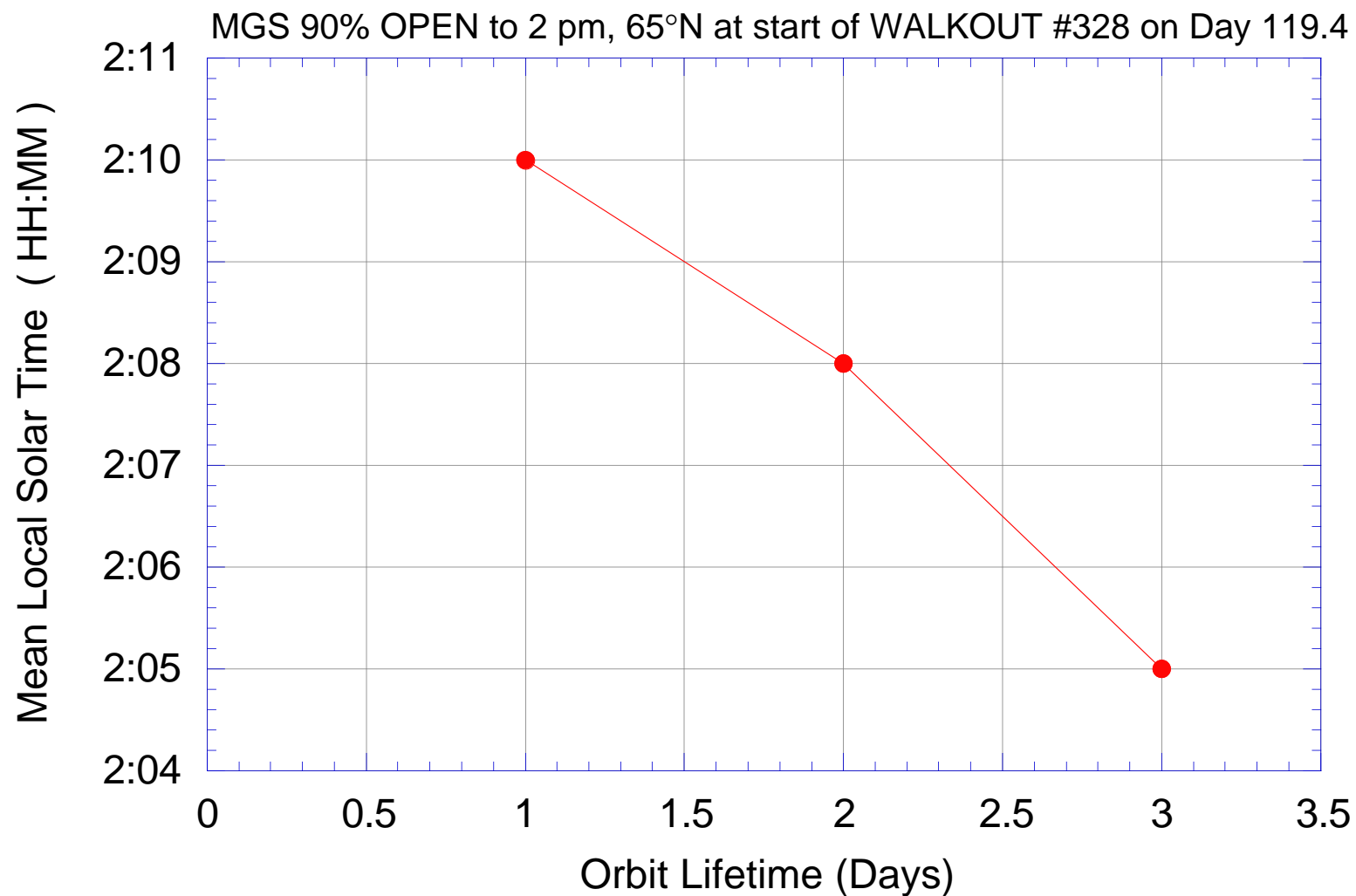# Scale Heights Inferred from MarsGRAM 3.4 Densities
And printed by MarsGRAM LIST file.

Legend:
- Inferred Scale Height (red dots)
- MarsGRAM Scale Height (blue line)

Y-axis: Scale Height (km)
X-axis: Altitude (km)

WALKOUT TRADEOFFS

LATITUDE at ABX (& Power) vs Lifetime

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MGS 90% OPEN to 2 pm, 65°N at start of WALKOUT #328 on Day 119.4

Drag Centered on Eclipse

Latitude of ABX
for the BASELINE

LATITUDE of Periapsis at ABX

Orbit Lifetime (Days)

Number of Days vs Orbit Lifetime

MGS 90% OPEN to 2 pm, 65°N at start of WALKOUT #328 on Day 119.4

Change In MEAN Local Solar Time

MGS 90% OPEN to 2 pm, 65°N at start of WALKOUT #328 on Day 119.4

Number of Orbits During Walkout

MGS 90% OPEN to 2 pm, 65°N at start of WALKOUT #328 on Day 119.4
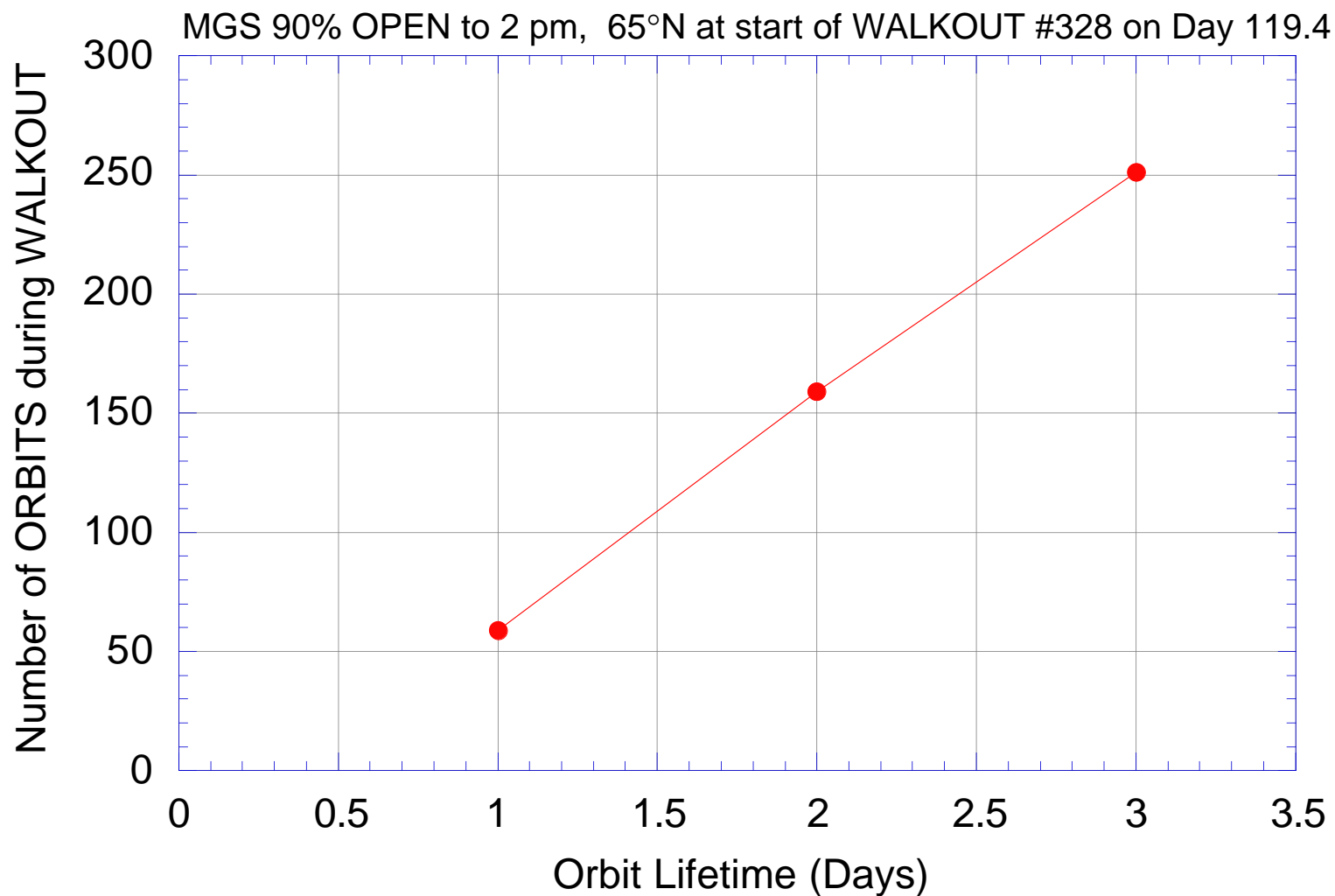
Periapsis Altitude at ABX

MGS 90% OPEN to 2 pm, 65°N at start of WALKOUT #328 on Day 119.4

Translational ΔV During Walkout

MGS 90% OPEN to 2 pm, 65°N at start of WALKOUT #328 on Day 119.4
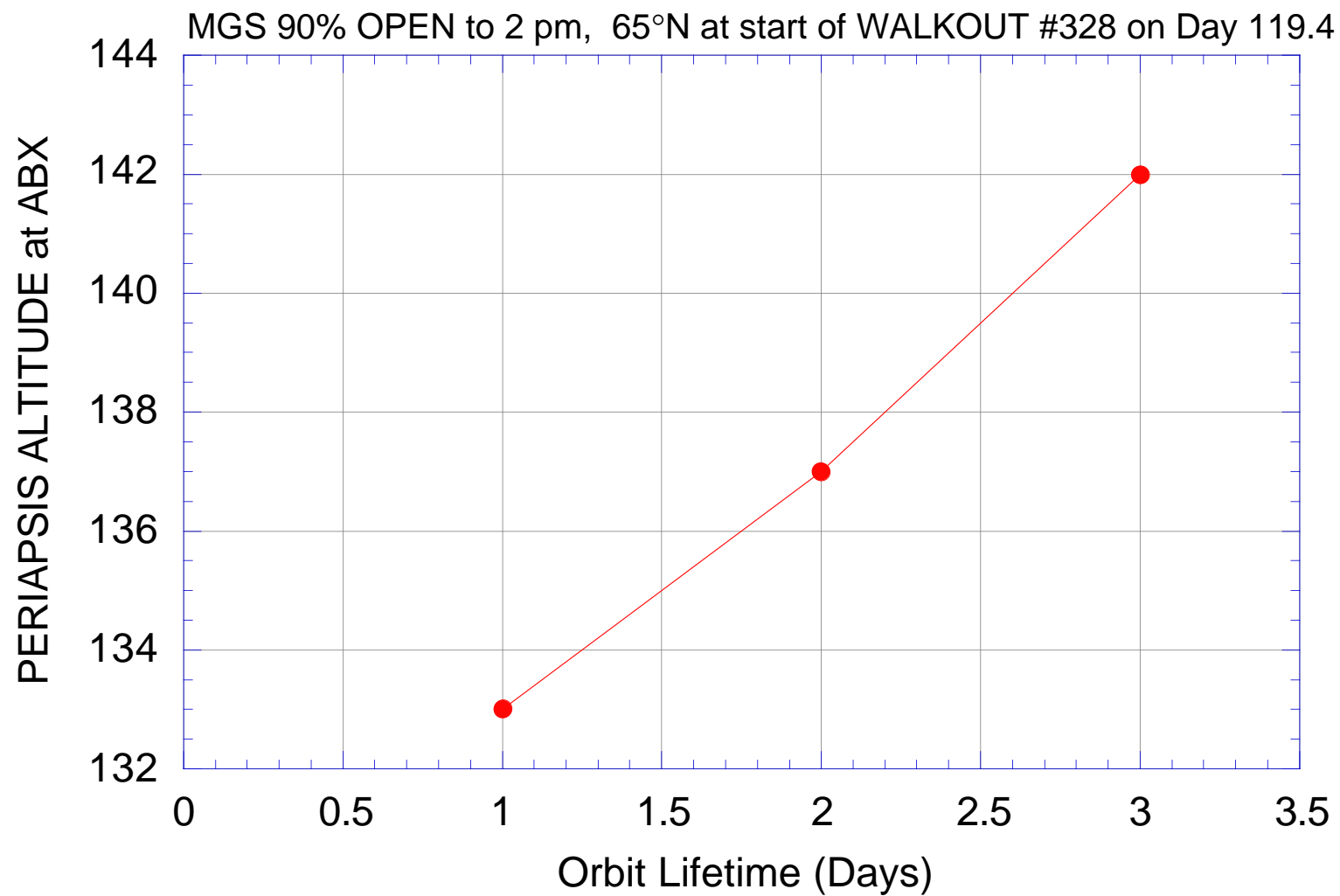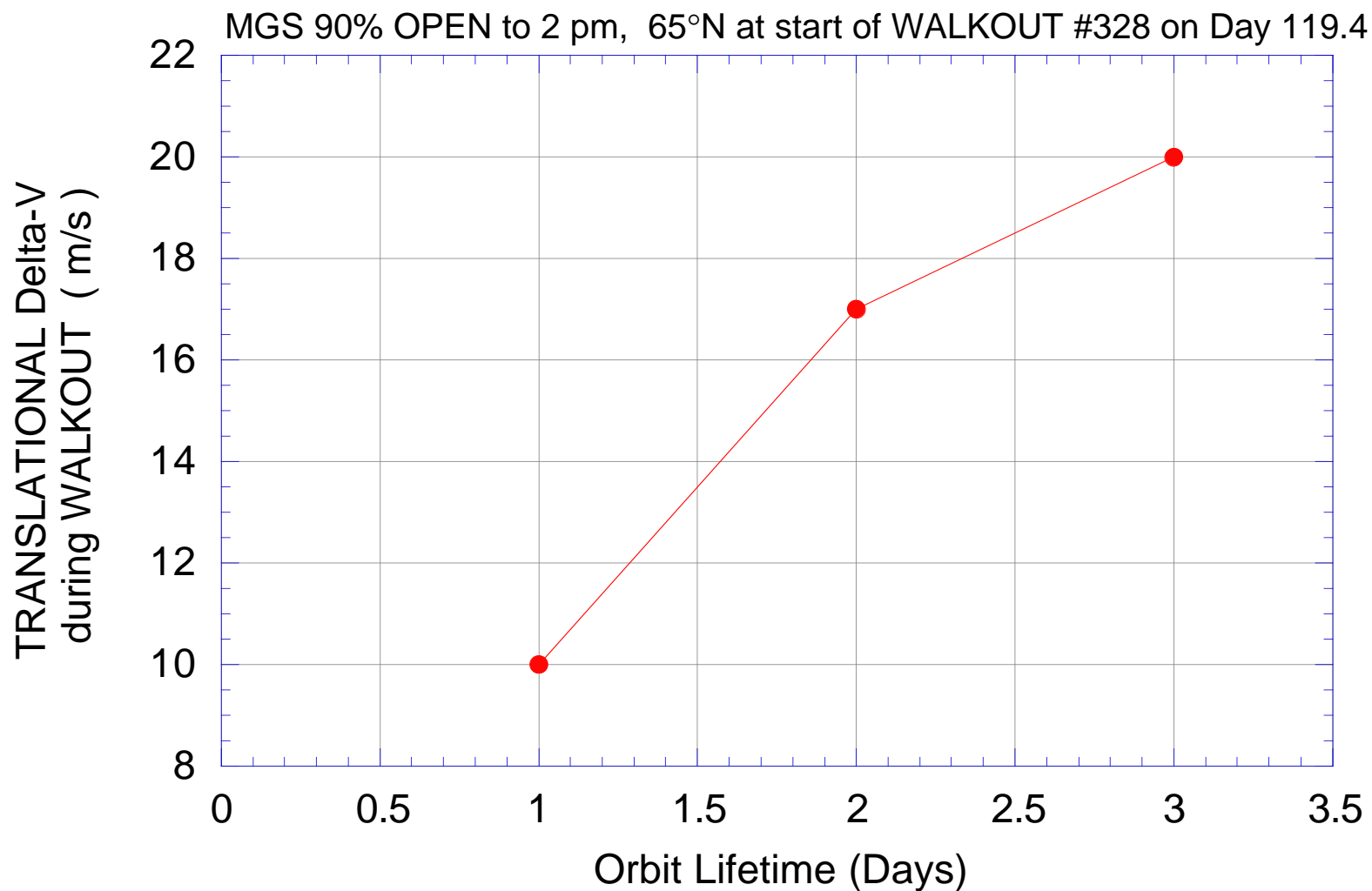
Sizes for Daily Maneuvers

MGS 90% OPEN to 2 pm, 65°N at start of WALKOUT #328 on Day 119.4

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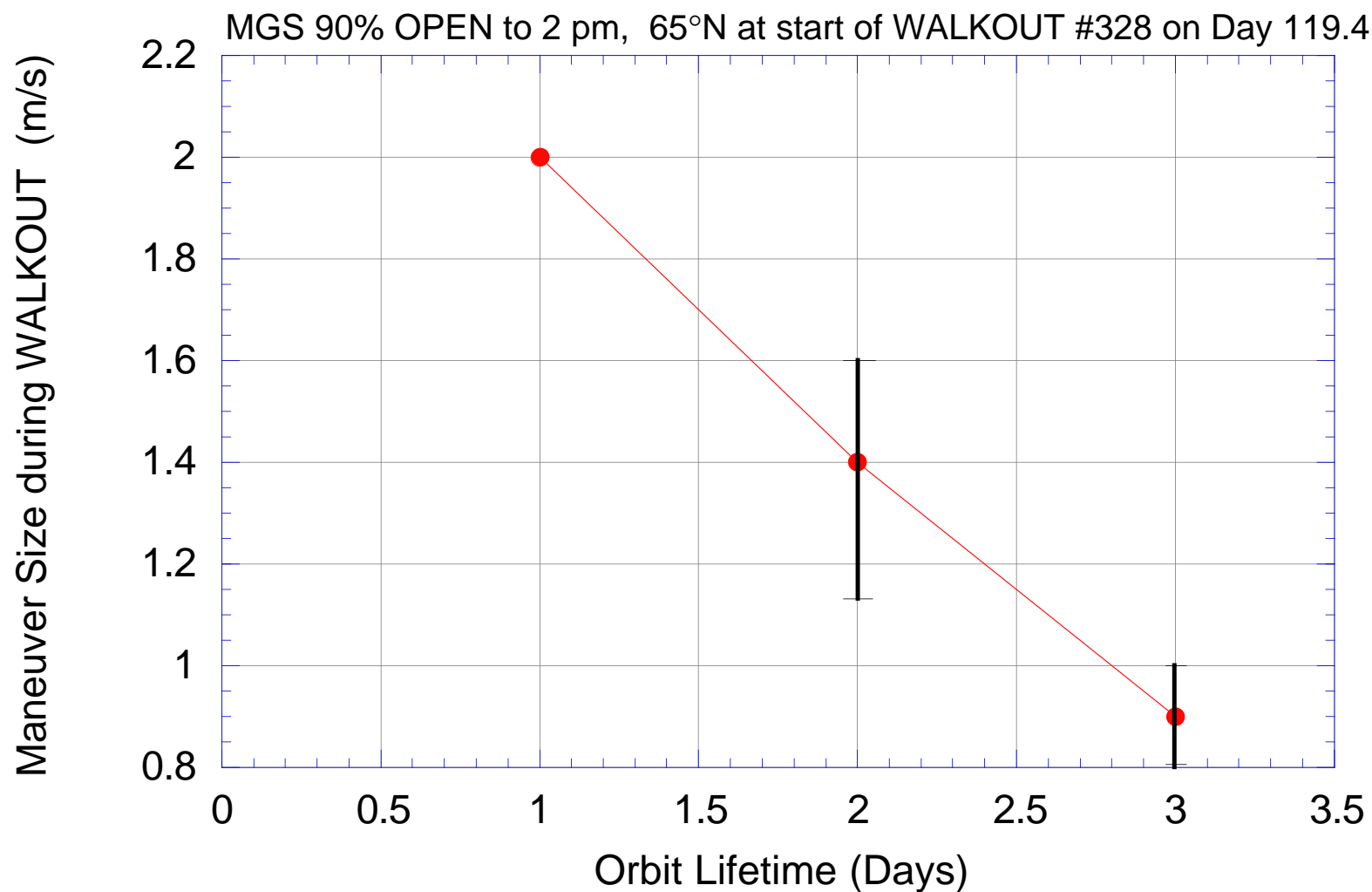
- ## Smaller Orbit Lifetime Means
  - Less Time to Recover from an Anomaly,   but
  - Less Time at Risk of an Anomaly.
  - Less Translational (and AACS) ΔV.
  - Can Pick Lifetime to Center ABX in the Eclipse for <u>Power</u>.
  - Can Reduce Intensive Operations Period by 1 - 2 weeks.
  - Can affect final Local Solar Time by 5 minutes.
  - Can reduce the number of Orbits by 150 Orbits.

- ## What Orbit Lifetime Should we Plan for ?